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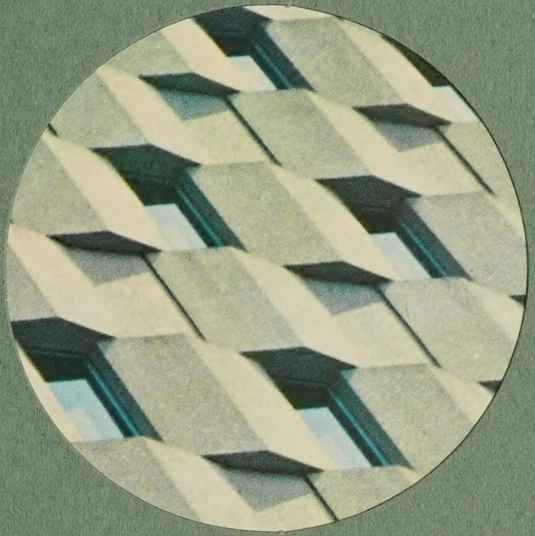

Concrete curtain walls

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PORTLAND CEMENT ASSOCIATION

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SURFACE ESTHETICS . . .

Concrete curtain walls

Art and technology in architecture are returning as the most exciting architectural story since medieval man built the lofty Gothic cathedrals in Europe. This is a new age of moving dynamic shapes and forms colorfully expressing the delight of man's achievement.

A marvel of this new age is the concrete curtain wall—a milestone in the evolution of surface esthetics in American architecture. These versatile and plastic surfaces, which combine form and color with structural appearance, offer exciting visual experiences that are lacking in other less plastic and durable surface materials. Concrete, the Cinderella material of the times, offers to architecture a dynamic new dimension in the multicolored, patterned and textured curtain wall. Sculptural wall and panel surfaces, by integration of form, function and material, impart new and economical trends to surface esthetics.

Walls still must provide insulation and low-cost protection from the elements. However, it is now expected that walls will fulfill these requirements with a cross-section and weight reduced to new lows, commensurate with proper performance. These new "curtain walls" also have to be quickly and easily erected. Developing a curtain wall that combines these qualities has been a challenge for architects, engineers and wall panel producers.

This booklet is intended to show how concrete curtain walls combine the diverse advantages desired in this type of construction. Your local precast concrete wall panel producer will be happy to give you full particulars on such matters as available colors and textures, handling and attachment details, and costs.

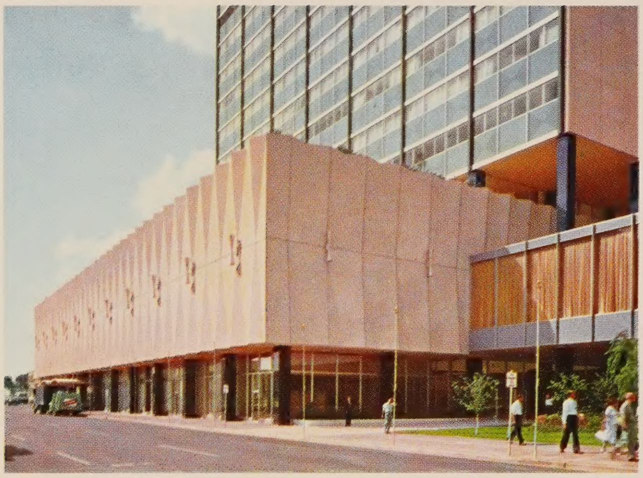
The range in shapes, sizes, designs, textures and colors offered by concrete wall panels is unparalleled in this work. Not only are the geometric, straightline shapes and designs possible, but practically any free form can also be realized. Colors range from white and delicate pastels to dramatic deep hues sure to dramatize any structure. Textures vary from glassy smooth to rough and bold.

Concrete curtain walls ensure staunch protection from the elements. Many perfected airtight and watertight joint details have been developed. Panels are securely attached to the structure. Fenestration can be designed in many ways. Excellent insulating properties minimize uncomfortable radiation of cold along the perimeter of the building and prevent expensive summer heat gain in modern air-conditioned towers.

The use of lightweight concrete and perfected connection details makes concrete wall panels easy to transport, handle and erect. Lifting inserts and attachment devices can be cast into the panels to minimize erection time and effect greatest stability to the connection.

Cross-sections of concrete curtain walls are often narrower than those of other materials because they require little, if any, backup. In many cases, the inside face of the panels can be left as furnished or merely painted. If a plaster face is desired, it can be applied to the inside panel surface.

All of these factors figure in the question of cost. When comprehensive studies are undertaken of everything that affects the cost of several types of curtain walls, concrete emerges as the one truly economical material. For the architect, it means that concrete is a newer, lower-cost curtain wall material offering an unprecedented freedom in design.



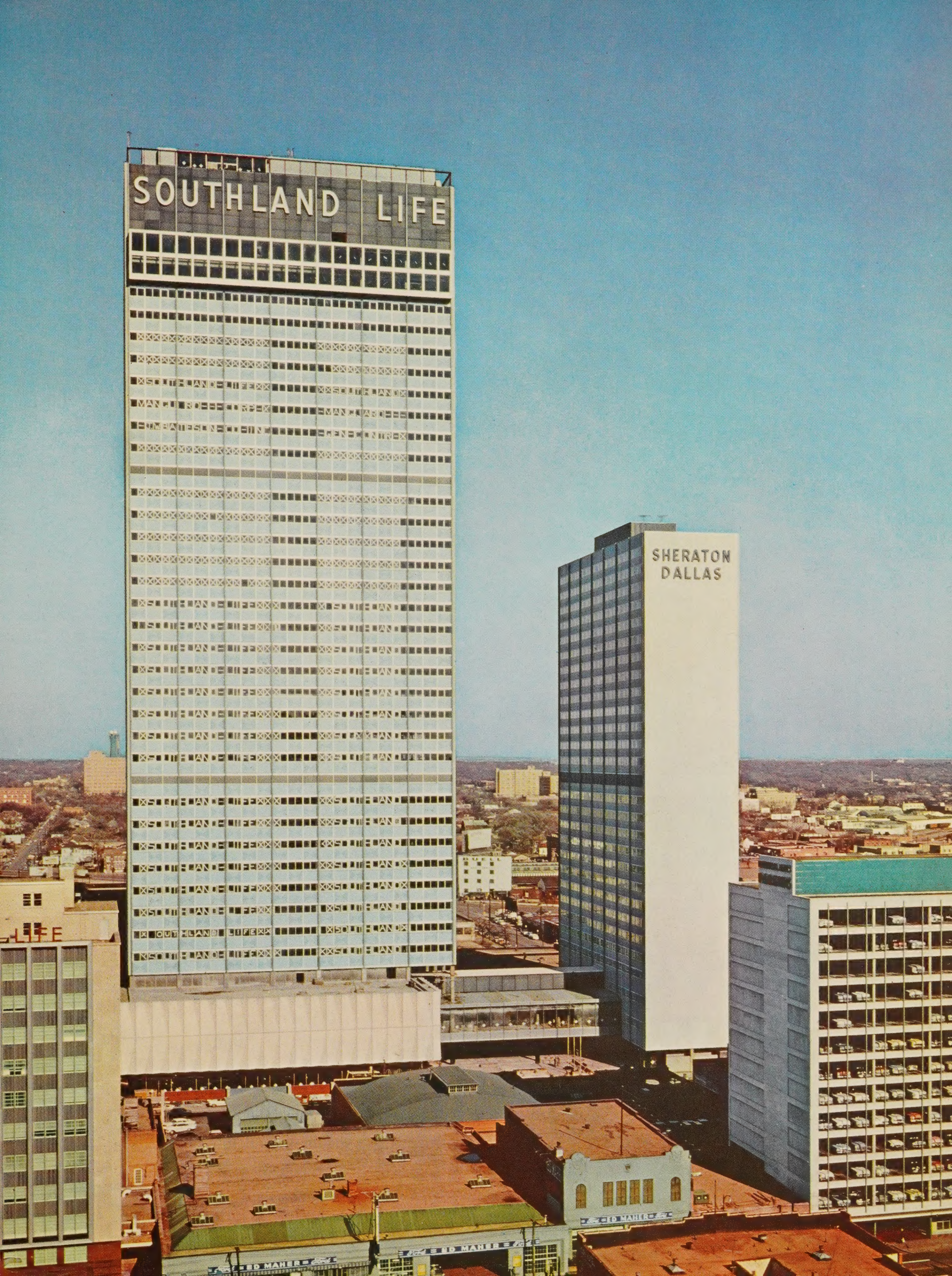
A pair of giants in Texas

Precast panels sheathe this pair of towers—the 42-story Southland Life Insurance Co. office building and 28-story Sheraton-Dallas hotel. Curtain walls on these buildings are similar. Sidewalls have spandrel panels with Italian glass mosaic tile cast in the surface. Endwall panels were cast with a mix containing white quartz aggregate and white portland cement matrix.

Erection of the panels was simple, fast and low in cost. The units were simply lifted from trucks, fastened to the frame and the joints sealed.

SOUTHLAND CENTER, Dallas, Texas

ARCHITECT-ENGINEER: *Welton Becket, FAIA, and Associates*, Los Angeles, Calif.
CONTRACTOR: *J. W. Bateson*, Dallas, Texas
PANEL FABRICATORS: *Wailes Precast Corp.*, Los Angeles, Calif., and Dallas, Texas
(exposed-aggregate panels)
McDonald Bros. Cast Stone Co., Fort Worth, Texas
(glass mosaic faced panels)


SOUTHLAND LIFE
SHERATON DALLAS
LIFE
ED MAHER

A festively faced resort hotel

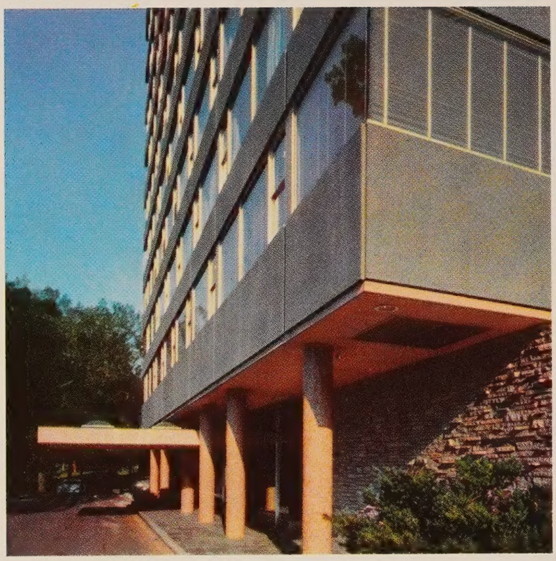
In character with the fun-loving spirit of its renowned location, the curtain wall of this Las Vegas hotel is eye-catching in its panoply of colorful patterns. The multicolored aggregates in the precast exposed aggregate panels make this building noteworthy even in a city known for its self-advertising structures.

L-shaped panels were used; windows were set in the resulting openings and sunshades placed above them. Only in concrete could panels of this unusual shape and with these brilliant colors be made economically. Despite a shipping distance of 450 miles, these precast panels proved competitive. Panels were hoisted directly from the trucks into position on the building.

FREMONT HOTEL, Las Vegas, Nev.

ARCHITECT: *Wayne McAllister and William Wagner,* Los Angeles, Calif.
STRUCTURAL ENGINEER: *John A. Martin,* Los Angeles, Calif.
CONTRACTOR: *Robert E. McKee General Contractor Inc.,* Los Angeles, Calif.
PANEL FABRICATOR: *Otto Buehner Co.,* Salt Lake City, Utah

FREMONT
RESTAURANT and BAR
GAMBLING-KENO
Ca



Tasteful curtain walls for luxurious apartments

The handsome spandrel panels on this exclusive apartment building were erected at the rate of a floor per day. These 2½-in. to 5-in. thick facing units were cast from about 3 to 6 ft. wide and in several lengths up to 24 ft.

Alternating strips of precast exposed aggregate panels and windows lend pleasing horizontal lines to this 10-story building. Although luxurious in appointments, this structure was built economically. Materials costs were low and the use of a reinforced concrete frame and precast wall panels made it possible to erect the building from foundation to roof in only 66 days.

3660 GRAND APARTMENTS, Des Moines, Iowa

ARCHITECT: *Brooks Borg*, Des Moines, Iowa
CONTRACTOR: *The Weitz Company*, Des Moines, Iowa
PANEL FABRICATOR: *Mid-West Concrete Industries, Inc.*, Des Moines, Iowa

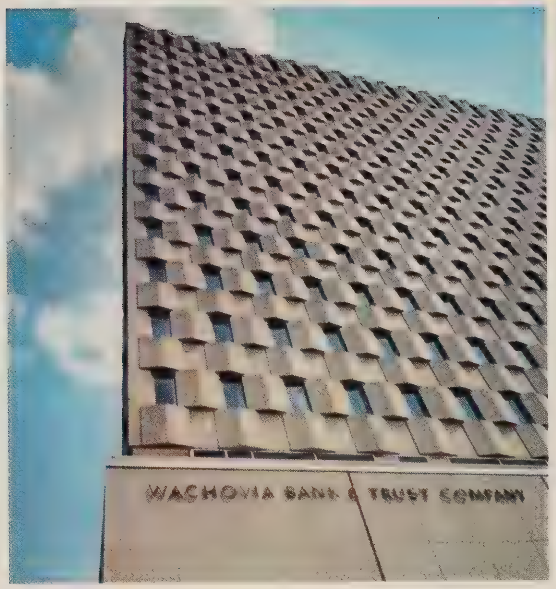
A glistening skin for a high-rise building

Towering 28 stories over Denver is this striking bank-office building. Faced with Georgia white marble aggregate panels, it is an attention-arresting structure by day and night. Surfaces of the wall panels were ground to a smooth finish.

The four-story base of the structure covers a 400 x 266-ft. plot. Over 100,000 sq.ft. of precast panels were used. Panels such as these offer the lowest maintenance available in curtain wall construction.

FIRST NATIONAL BANK BUILDING, Denver, Colo.

ARCHITECT: *Raymond Harry Ervin & Associates*, Denver, Colo.
ENGINEERS: *Phillips-Carter-Osborn, Inc.*, Denver, Colo.
Rhuel A. Andersen, Denver, Colo.
CONTRACTOR: *Meade and Mount Construction Co.*, Denver, Colo.
PANEL FABRICATOR: *Otto Buehner Co.*, Salt Lake City, Utah



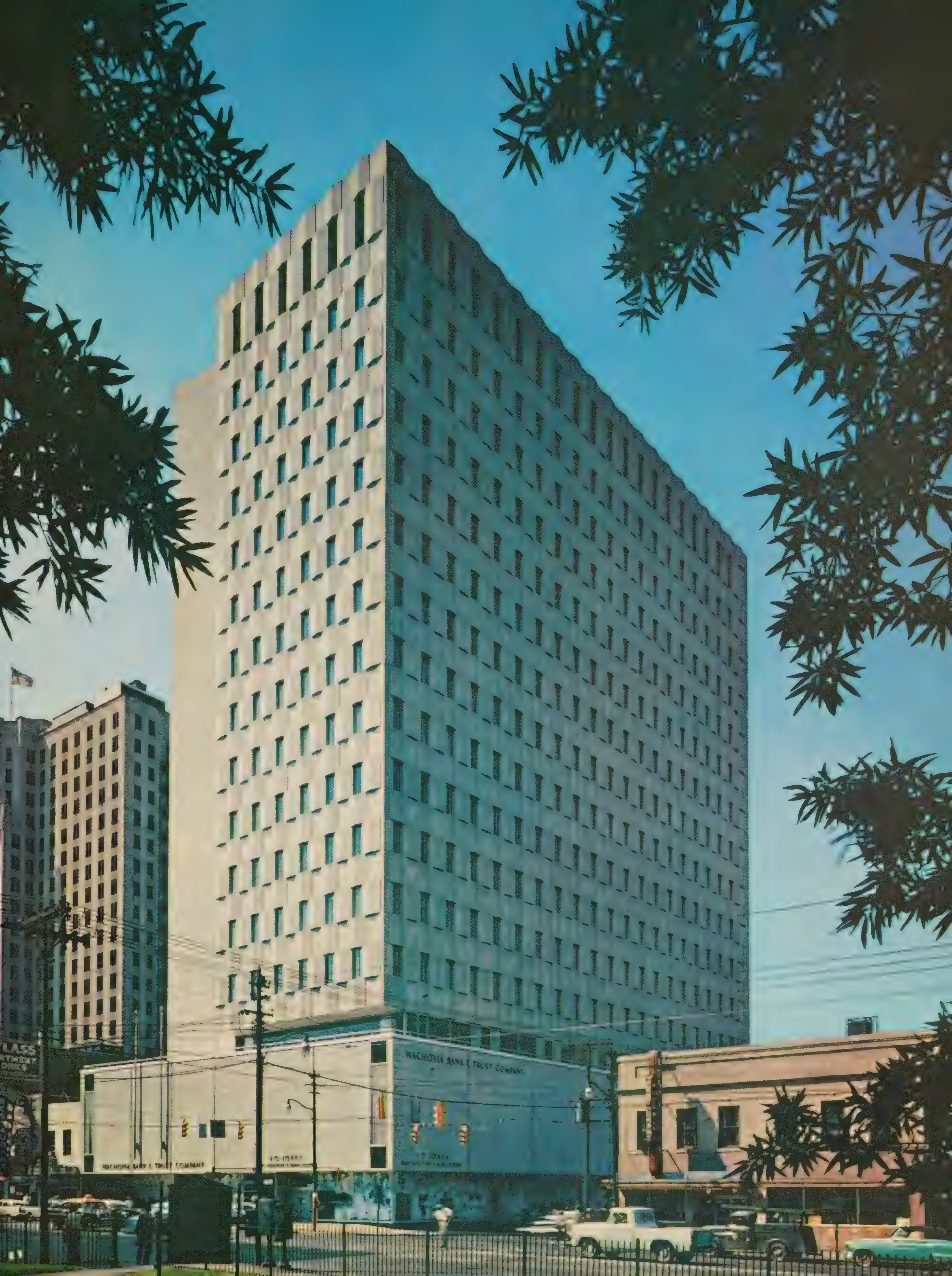
A memorable façade for a bank

Walls in banks and other financial institutions, in addition to fulfilling their usual practical functions, must inspire confidence and impart to clients a feeling of stability. In this 15-story bank-office building, precast concrete panels present a modern façade of imposing proportions.

Although panels are lightweight and have a relatively narrow overall cross-section, the wall has an appearance of considerable depth because units were cast with a thickened crown at mid-panel. Staggering the positions of the units resulted in a "checkerboard" pattern. From sunup to sundown, shadow patterns of the walls are constantly changing. Brilliance is added to the surface of the 3,800 panels by the white quartz aggregates.

WACHOVIA BANK & TRUST CO. BUILDING, Charlotte, N.C.

ARCHITECTS: *Harrison and Abramovitz*, New York, N.Y.
A. G. Odell, Jr., and Associates, Charlotte, N.C.
ENGINEER: *Severud-Elstad-Krueger*, New York, N.Y.
CONTRACTOR: *J. A. Jones Construction Co.*, Charlotte, N.C.
PANEL FABRICATOR: *Mabie-Bell Co.*, Greensboro, N.C.


WACHOVIA BANK & TRUST COMPANY
WACHOVIA BANK & TRUST COMPANY

Focal point for a shopping center

The harlequin pattern of black, white and grey which keynotes this large shopping center is stated in its most commanding form on the walls of this department store. Black and white aggregates were mixed together for the grey portions of the pattern.

Nine 8x14-ft. rectangular exposed aggregate panels per bay formed the triangular surface patterns. Use of lightweight concrete resulted in a low shipping weight and a low "U" factor. Built-in insulation provided by the panel made it unnecessary to provide any backup. The result—a curtain wall with an overall cross-section of only 6 in. Concrete panels proved competitive in cost even though they were shipped the 1,500 miles from the panel manufacturer to the building site.

WIEBOLDT'S DEPARTMENT STORE, Chicago, Ill.

ARCHITECT: *Barancik, Conti and Associates*, Chicago, Ill.
ENGINEER: *David B. Cheskin*, Chicago, Ill.
CONTRACTOR: *B-W Construction Co.*, Chicago, Ill.
PANEL FABRICATOR: *Otto Buehner Co.*, Salt Lake City, Utah

WIEBOLDT'S

Choosing a curtain wall

Walls constitute a major consideration in the overall design of any building. In high-rise structures, they are of paramount importance among the several building components. Curtain walls have gained considerable acceptance in recent years as the best method of supplying protection and beauty to buildings that rely on a frame for structural support.

Some of the factors that determine the selection of a curtain wall material are such esthetic considerations as colors, textures, patterns and panel shapes and such practicalities as cost, availability, handling and attachment, insulation, maintenance, and fire resistance. Let us examine the record of concrete curtain walls in the light of these considerations.

COLORS

In concrete curtain walls, architects are offered the widest choice of colors available in this field. Solid colors can be chosen from any portion of the spectrum—there are no charts of predetermined colors to limit the architect's imagination when he works with concrete.

But solids are only a small part of the color story in concrete curtain walls. Mixtures of aggregates of different colors and the influence of the matrix color give to an architect a peerless control of the coloristic effect for which he is working. With the calculation of the psychological impact of colors on humans now more of a science than an art, it is only reasonable that architects work within a medium capable of the nuances achieved by the science.

Aggregates used in the decorative facings for concrete curtain walls have ranged from clamshells to ball bearings for unusual applications. Those most frequently encountered, however, are of quartz, marble, granite, gravel, ceramic tile and various ceramic and vitreous materials.

Quartz aggregates are generally available in three varieties—clear, white, and rose (a light pink). Clear quartz is widely used since it adds a sparkling surface to panels that depend mainly upon their matrix for color. Therefore, it is adaptable to use with any color panel. It may also be used in combination with colored aggregates to emphasize the matrix. White quartz ranges from a translucent white, verging on the clear type, to a deep milky white widely used for curtain wall panels. Rose quartz aggregates produce concrete ranging from a delicate pink to a warm, aged-looking rose color.

Marble offers architects the widest selection of colors among the natural aggregates, namely, green, yellow, red, pink, blue, grey, white and black. In most areas, blue and yellow marble aggregates are available in pastel hues and the other colors in many shades running from light to moderately dark.

Granite, long known for its durability and beauty, is available in shades of pink, grey, black and white. It is usually composed of 30 per cent quartz and 70 per cent feldspars.

In certain sections of the country, a pleasing brown or reddish-brown gravel is available. In these areas it has been used to produce attractive, low-cost wall panels.

A number of manufactured aggregates are available in the United States. These extend the range of colors in concrete curtain walls into the vibrant, bright shades that prove valuable for architectural accents. A comparison of typical colors of natural and manufactured aggregates can be made by contrasting Figs. 1 and 2. The latter are generally custom manufactured to match samples submitted by the architect.

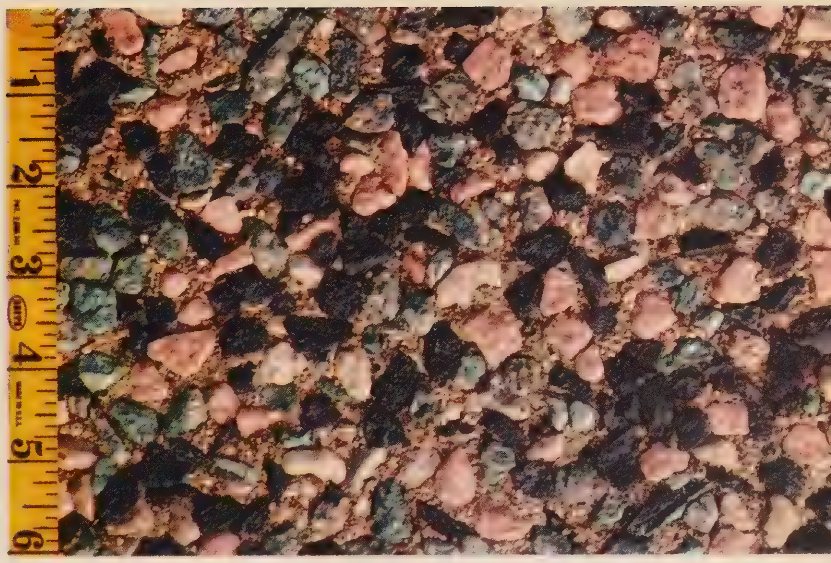


Fig. 1. *A mixture of marble aggregates in several colors produced this panel surface.*

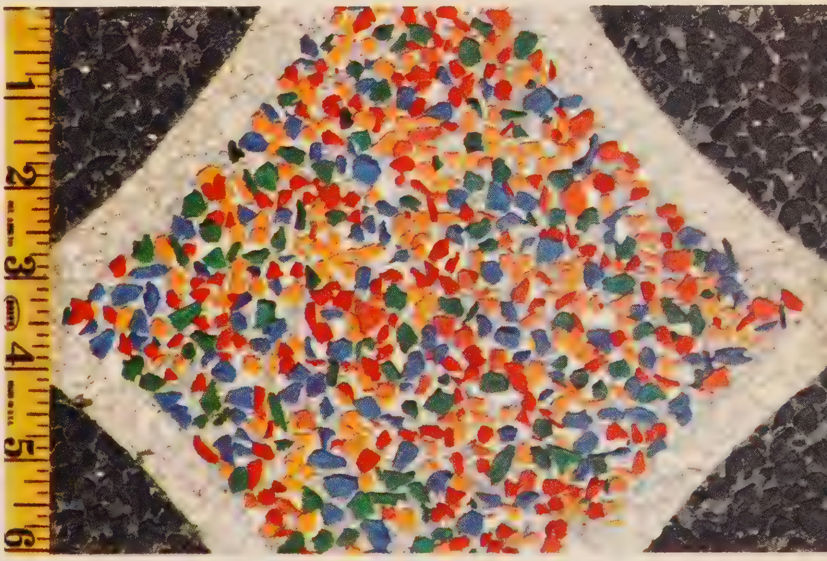


Fig. 2. *Vitreous aggregates in several bright colors created this colorful design.*

In this category are such aggregates as those made of vitreous and ceramic materials and ceramic tile.

Ceramic facing tiles are available in a dazzling array of colors and patterns. The tiles, inlaid in neat, regular rows, constitute up to 90 per cent of the panel's exposed surface. Tiles can be obtained in a wide variety of sizes but 1-in. square and 1x1½-in. tiles are common.

Ceramic aggregates lend drama to panels through the richness and luster of their coloring and surface. In common with all the manufactured aggregates, it is possible to get practically any color when using a ceramic material.

Vitreous aggregates and tiles provide the most intense colors of the materials commonly used for decorative concrete curtain wall panels. They are often used for murals, signs, and other applications requiring eye-catching beauty.

The matrix has an important bearing on the overall color of the panel. Curtain wall panels can be made that depend mainly upon the matrix to achieve the desired color. Transparent quartz aggregate is used to heighten the luster and coloring of the panel as well as to add a durable surface.

In panels made with colored aggregates, the matrix color can either subtly mute or clarify the color. White portland cement is usually used in the facing mix to ensure utmost purity of color, even in many of the darker shades.

Coloring of the matrix is accomplished through the use of mineral oxide pigments. Practically all colors can be obtained in this manner, including light to dark shades of red, green, yellow and brown.

Intermediate shades of both achromatic and chromatic colors are cast by manipulation of the matrix and aggregate colors. Many unusual pepper-and-salt and similar effects can be obtained by mixing multicolored aggregates of fairly large size in a white portland cement matrix to eliminate visual merging of the colors. In addition to these mosaic-like panels, it is possible to achieve luminous colors with fascinating color-on-color effects that add interest and character to otherwise unornamented walls.

Concrete curtain walls can be created in a virtually unlimited range of colors. Not only are the primary colors readily obtainable, but through juxtaposition of mixed aggregates in colored matrices, it is possible to produce a multitude of mutable hues.

TEXTURES

Closely allied with color and materially affecting it is the consideration of surface textures. Naturally, a matte finish will alter the apparent color of a panel when compared with

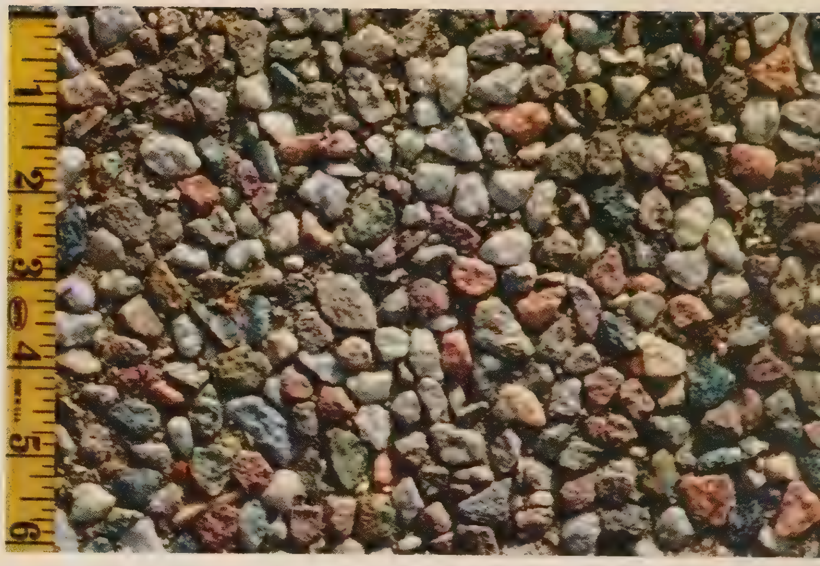


Fig. 3. *A surface texture exposing $1/4$ to $3/8$-in. aggregates was achieved by the aggregate-transfer method.*

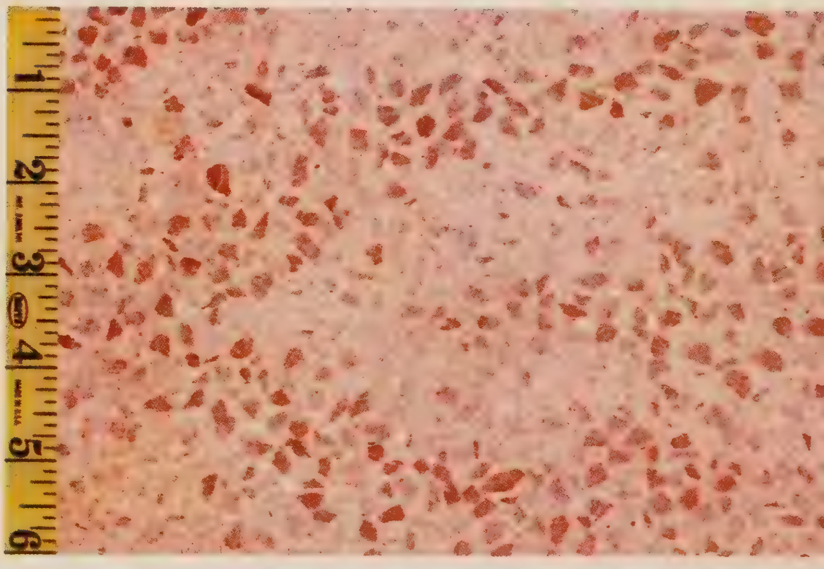


Fig. 4. *This exposed aggregate surface was ground to a smooth finish.*

one finished smooth. Texture also helps determine the relative visual importance of a wall; for example, moderately rough finishes usually are less obtrusive than shiny surfaces. The textures of concrete curtain wall panels range from a glossy, ceramic-like finish to rugged textures of bold outlines.

An exposed aggregate panel commonly used for curtain walls has an aggregate reveal of approximately ⅛ in. Reveal is largely determined by aggregate size; the greater the maximum aggregate size, the deeper will be the reveal. It can be varied by several casting techniques. A retarder can be used on the forms as the panels are cast face down. The surface mortar is later brushed to expose the aggregate more fully. A shallow layer of sand is sometimes placed in the bottom of the form to cover partially the decorative aggregate which increases reveal. Figs. 1 through 4 are close-ups of exposed aggregate panels. Aggregates 2 in. to 3 in. in diameter were used for the bold texture on the panels illustrated in Fig. 6.

The question of propinquity of traffic flow to curtain walls has an important bearing on the extent of aggregate reveal desired. When panels are to be viewed relatively close, such as those bordering walkways, less reveal is needed. When panels are to be some distance from the main flow of pedestrian traffic, greater reveal will be needed for a rough-textured look.

Exposed aggregate panels ground smooth take on a terrazzo-like appearance. Such panels have an attractive sheen that enhances many colors. Polished panels of pastel colors tend to appear white when viewed from afar due to the high reflectance of the surface. Therefore, this type of surface is recommended for panels situated relatively close to the traffic flow or for those of medium or dark shades.

Ultrasmooth or lightly textured panels can be cast through the use of plastic form liners. These form liners are made from a plastic sheeting which is glossy on one side and which has an embossed leather design on the reverse side. When the concrete is cast against the smooth side, the color takes on new depth and dimension. Examples of panels cast with plastic form liners are shown in Figs. 5 and 18.

Carpet-like textures of various patterns are possible with panels cast against rubber form liners. Fig. 7 illustrates a common design obtained with rubber form liners.

The foregoing textures are only a few of those that are commonly encountered in concrete curtain walls.* A wealth of additional

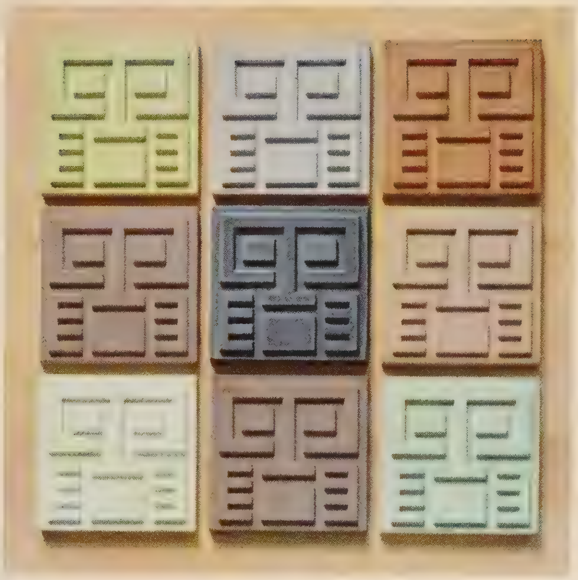


Fig. 5. *Integral colors take on a new depth and richness when panels are cast against plastic form liners.*

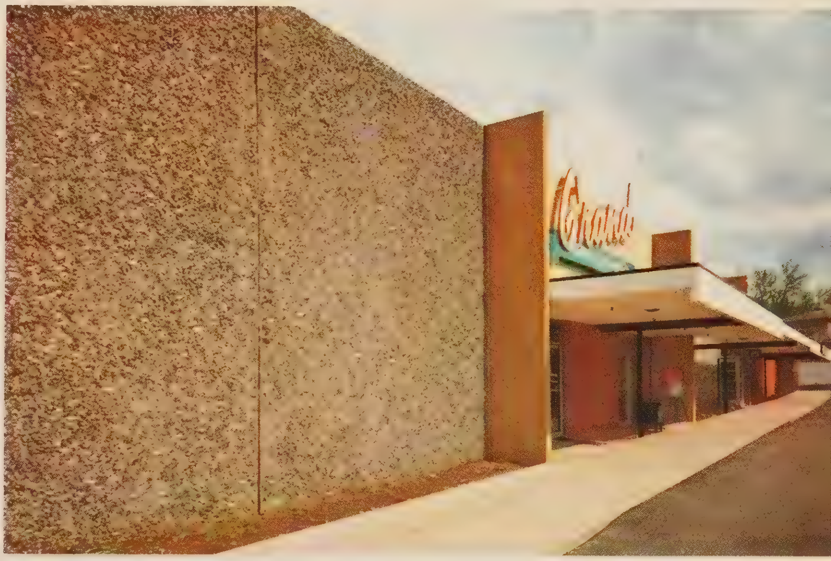


Fig. 6. *Large concrete panels for the Grand Super Market, Riverside, Calif., were cast at the job site and lifted into place. A rough texture was achieved by exposing large aggregates in the panel surface.*

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*Additional information on concrete surface textures is available in the United States and Canada from the Portland Cement Association, 33 West Grand Ave., Chicago 10, Ill.

textures are available. For example, some of those obtainable through the use of form liners include the surface textures of concrete cast against striated plywood, roughly sawn boards, sand-blasted plywood and the screen side of masonite. Panels can also be textured after curing by mechanical means such as bush-hammering, tooling or sandblasting as shown in Fig. 9.

In the matter of textures, concrete curtain walls open to architects the widest range and greatest opportunities for personal expression of any currently available material.

PATTERNS

Because of the protean nature of plastic concrete, it is admirably suited to patterning. The following three basic approaches are most often used to create designs in concrete curtain wall panels: (1) high and low relief, (2) colored aggregates, and (3) contrasting textures.

Relief designs of practically any form can be achieved with concrete panels. Both straightline geometric patterns and free-form shapes of unlimited numbers are possible.

Straightline figures are most often realized by the use of negative patterns made of wooden strips or metal molds in the forms. Concrete can be cast directly on the patterns or decorative aggregates can be spread on the forms and concrete cast afterward to produce a relief design with an exposed aggregate surface. An alternate method uses a concrete mix with white portland cement paste and decorative aggregates for the facing backed up by several inches of lightweight concrete.

Several methods of casting free-form patterns in concrete curtain wall panels are currently being used. The techniques used for making straightline patterned panels can also be used for free-form decorations. Plaster waste molds often prove to be most practical when intricate shapes are to be formed. If added emphasis is desired for certain portions of a relief pattern, aggregates of a color that contrasts with the background can be applied to the desired portions of the design.

Plastic form liners offer the means of obtaining both straightline and free-form patterns on concrete wall panels. After a design has been decided upon, a wooden or plaster negative pattern mold is made. With the mold and the usual vacuum forming technique, it is possible to make any number of form liners of the thermoplastic material used in this work.

Virtually any design can be achieved in plastic form liner work as long as the following three rules are observed: (1) Limit depth of design to ½ in. to 1 in. in most cases. (2) Maintain a 10-deg. draft on all indentation

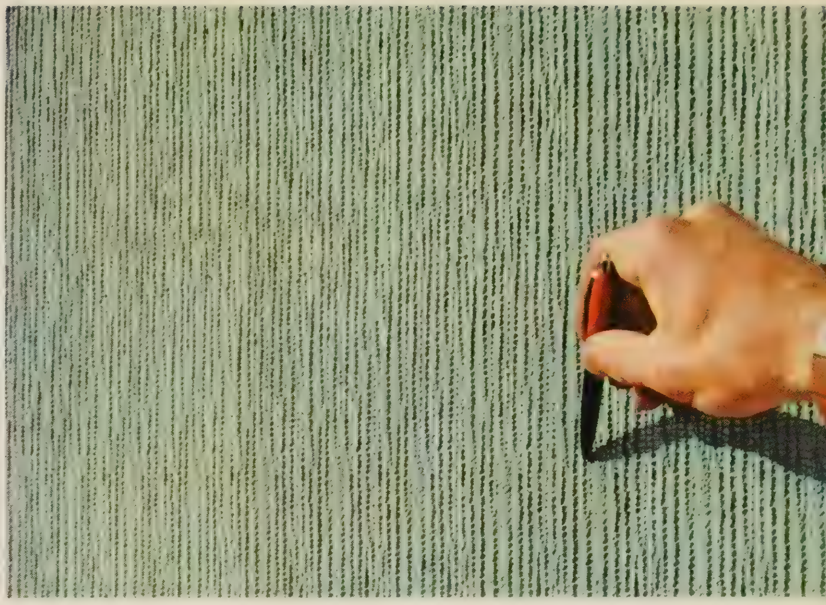


Fig. 7. *This precast panel is one of many used to enclose a parking garage in Athens, Ga. The textured surface was made by casting concrete against a rubber matting form liner. Architect: Heery & Heery; contractor: C. C. Robertson, both of Athens.*

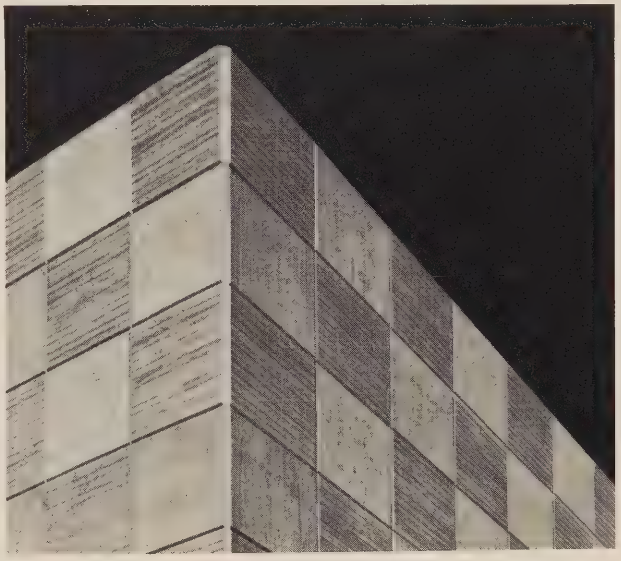


Fig. 8. *A rough texture created by casting plain concrete against alternating panels of sandblasted form boards.*

sides. (3) Keep all edges and corners rounded. Relief may be more than 1 in. if the depressed area is sufficiently wide.

There are several methods by which designs can be obtained through the use of colored aggregates. One technique commonly employed outlines the desired pattern with narrow wood or metal strips. The predetermined colored aggregates are placed in the appropriate outlined sections, the strips are removed and white portland cement concrete is cast atop the decorative aggregates. When backed up with a grey concrete mix, the result is a strikingly attractive curtain wall panel.

Another means of producing colored aggregate designs is the aggregate-transfer technique. In this method, colored aggregates are placed on a plywood form liner coated with adhesive. After the adhesive has hardened, concrete is cast against the liners and cured. Since the bond of the aggregate is greater to the concrete than to the adhesive, the aggregate is "transferred" to the surface of the concrete when the liner is stripped.*

The profusion of decorative aggregates of varied colors and textures enables architects to achieve unique architectural effects through patterns using several types of natural and/or manufactured aggregates. Full-color designs can be anything from a simple circle or diamond pattern (Fig. 10) to elaborate designs (Fig. 11).

Innumerable patterns are possible through the manipulation of concrete surface textures. A few of the textures available were mentioned in an earlier section. The opportunity for designs through texture is obvious to any architect. Rough form boards can be laid in a random pattern. Rubber form liners might be cut into squares and set with their linear texture running at 90-deg. angles to contiguous squares. Panels cast against the textured side of plastic form liners can be arranged in leather-like square patterns. The possibilities are unlimited.

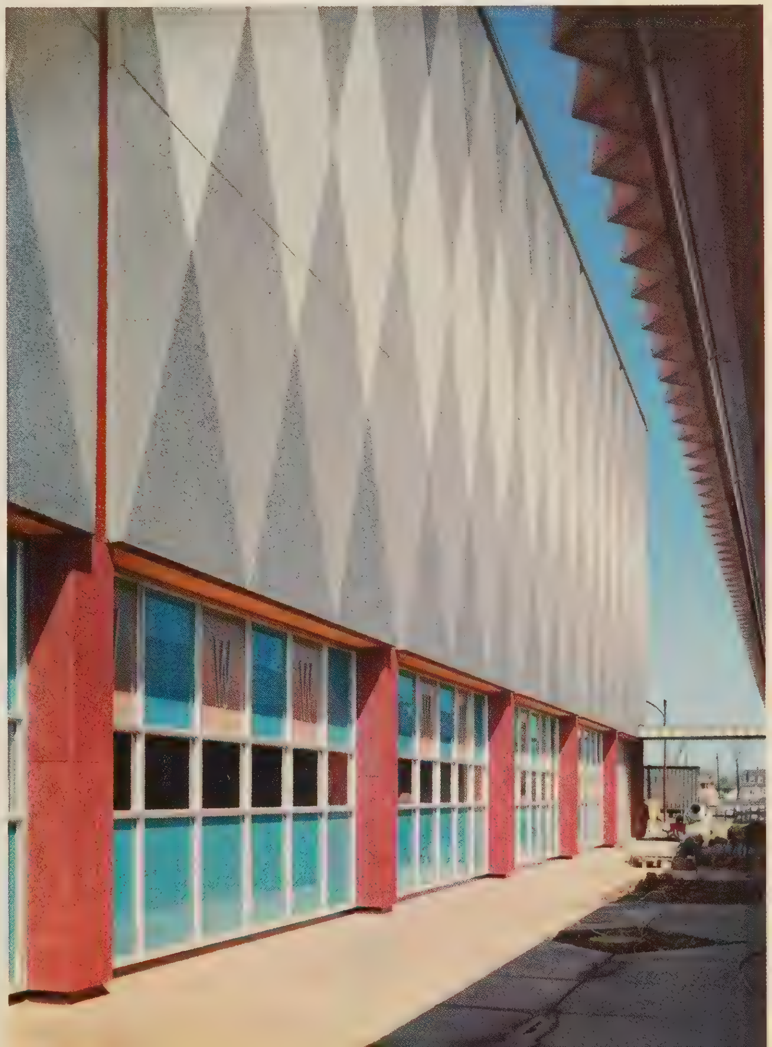
And "unlimited" is an apt word to describe the entire gamut of pattern possibilities open to architects specifying concrete curtain walls. In no other medium is it possible to enjoy the freedom of design through the multiplicity of controlled effects—relief, color and texture.

PANEL SHAPES

Concrete panel shapes have ranged from the ubiquitous rectangular panel to square, diamond, curved and multiplanar panels. Unusu-

Fig. 9. *Concrete surface textured by bushhammering after removal of forms.*

Fig. 10. *Color and pattern in these wall panels were achieved by a colored concrete matrix and clear quartz aggregate with the columns accented by covers of thin red panels.*



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*Additional information on the aggregate-transfer method is available in the United States and Canada from the Portland Cement Association, 33 West Grand Ave., Chicago 10, Ill.

ally shaped panels are much easier to manufacture in concrete than in other materials due to the plasticity of concrete as it is being cast. A pleasant departure from severe rectangular building shapes is shown in Fig. 12 which shows exposed aggregate panels that are sculptured to the curving lines of a library bay. L-shaped panels, such as those in Fig. 13, reflect the patterns set up by the sunshades and resultant shadows that are an integral part of the façade of this building. Panels thickened at midsection alternated with flat panels and windows result in an attractive three-dimensional wall with a checkerboard pattern on the office building pictured on page 13. Fig. 14 depicts the striking decorative effect obtained by erecting square panels diagonally.

Precast concrete curtain wall grilles have won considerable popularity because they combine beauty and practicality. Two types are commonly encountered—punctured concrete panels, such as those shown in Figs. 15 and 16, and relatively small units erected much the same as concrete masonry (see Fig. 17).

Concrete curtain wall panels can be cast with a grillework over all or part of the surface to achieve a delicate filigree beauty. Panels are most often used when the grillework is not to cover an entire wall of a building. For more extensive areas, masonry units especially cast to create the desired pattern are eminently satisfactory. One of the three following face sizes is usually specified for these units since they conform to the mold boxes of standard block machines: 8x8 in., 12x12 in., or 8x16 in. A stacked bond is most often used in this work since it maintains the geometry of patterns and produces unbroken edges at wall openings.

Thus, in all the design variables—colors, textures, patterns and panel shapes—curtain walls of concrete prove to be the most versatile available for this work.

COST

An artist must work within the restrictions imposed by his art and himself. Architects, too, cannot be swayed solely by the design possibilities offered with the use of a material. They must also consider such practicalities as cost, availability, handling and attachment, insulation, maintenance, and fire resistance. Fortunately, in terms of practicalities, as well as esthetics, concrete curtain walls have the scales tipped heavily in their favor.

Attention has been called several times to the value of concrete's plasticity and sculptural qualities in broadening design possibilities. These characteristics also simplify the manufacture of precast wall panels, thereby lowering their cost considerably. Unusually shaped con-

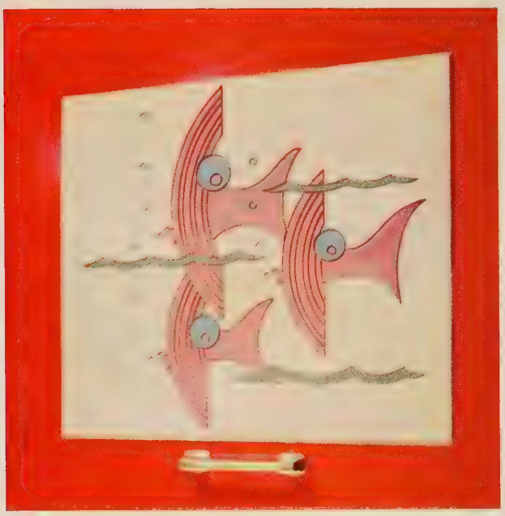
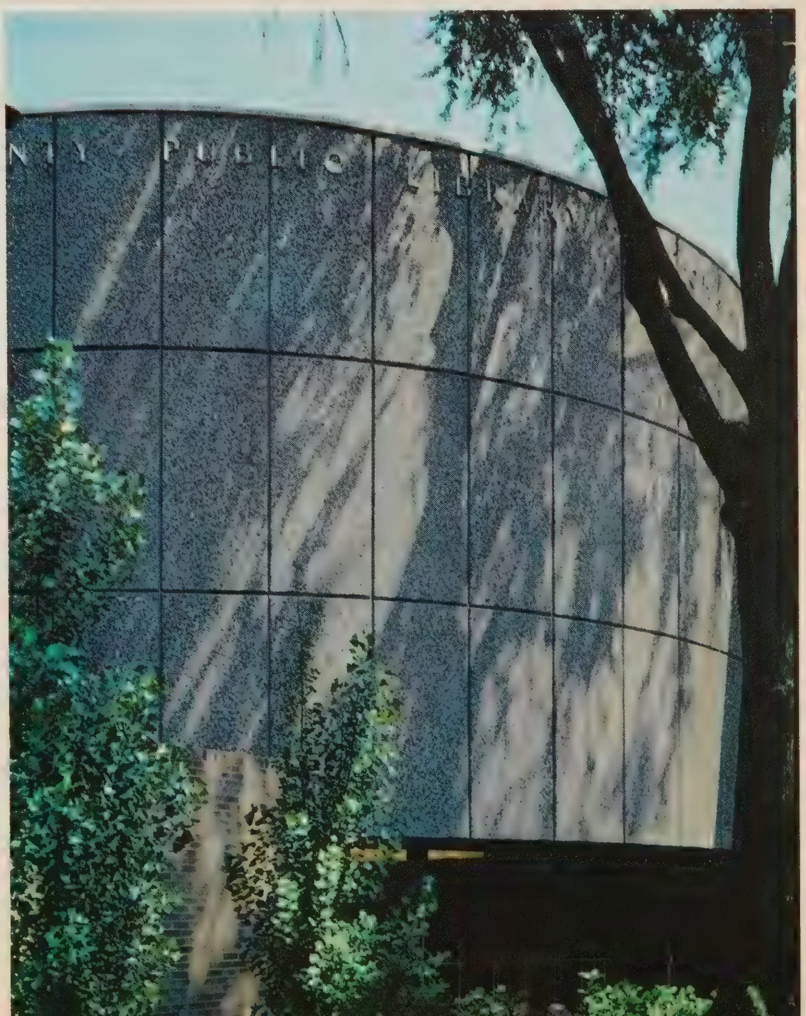


Fig. 11. *This stylized fish illustrates the free-form designs that can be achieved in exposed aggregate panels.*

Fig. 12. *Curved concrete panels enclose the reading room portion of the City Library in Charlotte, N. C. An attractive exposed aggregate surface was specified by the architect, A. G. Odell, Jr., and Associates. The panels were made by Concrete Materials, Inc., for the general contractor, J. A. Jones Construction Co. All are located in Charlotte.*



crete panels are not materially more expensive than conventional rectangular ones. Even elaborate surface designs, such as those shown in Fig. 18, can be economically realized by several techniques.

In this country, the labor required to cast panels has a considerable bearing on ultimate cost. Unornamented concrete panels made with gravel and sand aggregates can compete successfully with the cheapest type of walling. As ornamentation becomes more extensive and intricate and as the panel cross-section grows more complex, the cost will naturally increase. However, a comparison with comparable competing curtain wall panels (if they are capable of the effects and uses of the concrete panels) will underline the economy of concrete.

In many cases concrete wall panels can be furnished that constitute the entire wall. This eliminates the need for expensive finishing of the interior wall surface. It also results in a wall of reduced cross-section when compared with competing panels with their backup and interior finish. Once the concrete wall panel has been erected, the wall is completed.

The materials for concrete wall panels are low in cost. The use of white portland cement in the matrix will enhance the clarity of colors obtained. Coloring the matrix will vary in price in proportion to the cost of the mineral oxide pigment and the depth of color desired. Shades of red, orange, yellow, brown, black and grey are especially inexpensive because these pigments are low priced and it takes a relatively small amount of pigment to color the matrix. Brilliant, deep yellows are usually difficult to obtain because suitable mineral oxides are not readily available. Deep shades of blue and green are ordinarily more expensive; but, since the facing mix is only 1 in. in depth, the cost of coloring the matrix is a relatively minor consideration.

Decorative aggregates vary in price in relation to the availability of natural aggregates and to the total cost of making manufactured varieties. Transportation also figures largely in the cost of decorative aggregates. Marble aggregates are generally available throughout the United States and are low in cost for most types. Quartz and granite are slightly higher in price than marble since their high density makes them more difficult to quarry. Gravel naturally is the lowest priced of all aggregates. The cost of ceramic materials is from three to five times that of marble. Vitreous aggregate, supplied uncrushed, costs approximately 10 to 12 times as much as marble.

However, even the most expensive aggregates often are practical because they are used only in the 1-in. facing layer. If the aggregate-

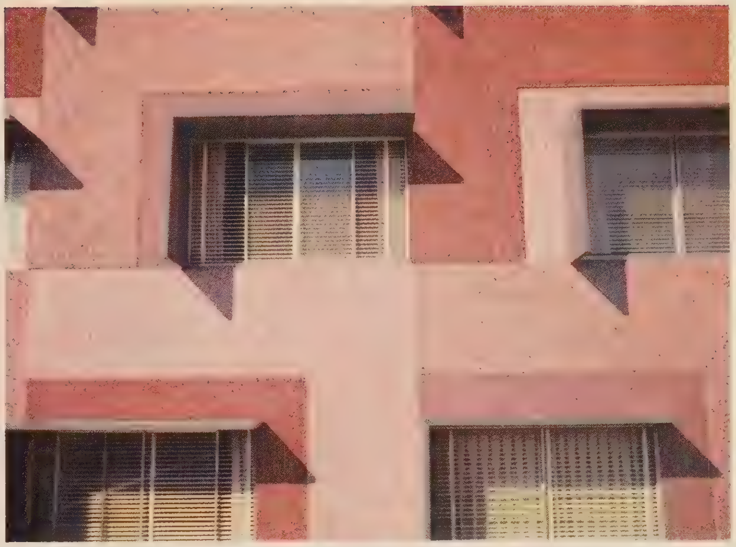


Fig. 13. *L-shaped panels with two colors of exposed aggregate were effectively used with L-shaped canopies accenting the pattern.*

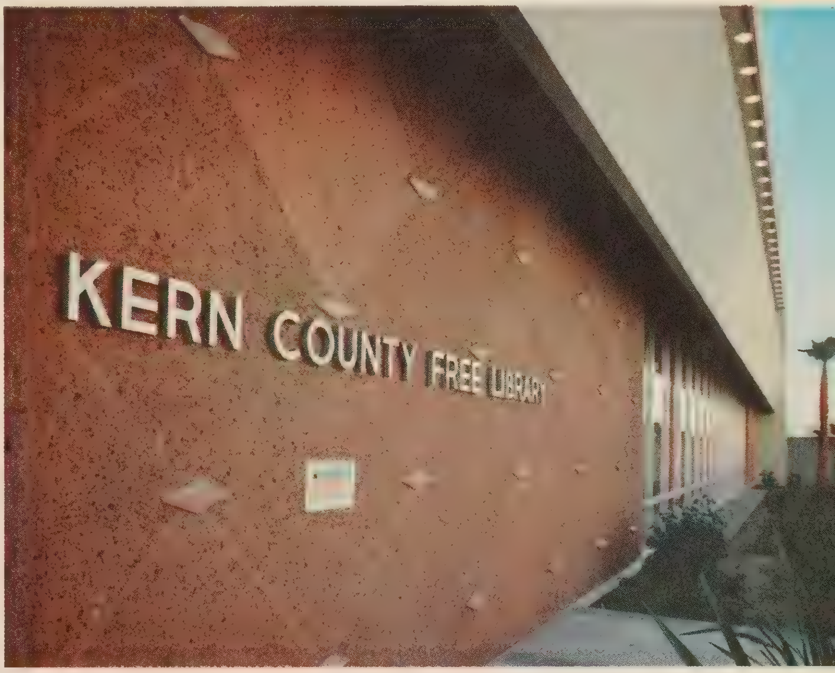


Fig. 14. *This modern library in Bakersfield, Calif., illustrates the use of square precast exposed aggregate panels rotated 45 deg. Small precast units were inserted at panel corners. The architect was Whitney Biggar, and the general contractor was Guy Hall, both of Bakersfield. Panels were made by the C. D. Wailes Co. of Los Angeles.*

transfer technique is employed, which applies a single layer of decorative aggregate on the surface of the panel, costs are accordingly lowered.

Another factor in cost determination is casting technique. As has been noted, aggregate transfer is especially economical when expensive decorative aggregates are used. The choice of casting procedure will be dictated largely by the physical and economic requirements of the project in question. Also, the matters of attachment and jointing details have an important bearing on costs.

Architects should consult a producer of precast concrete wall panels before plans are prepared. He can provide specific information on local concrete curtain wall construction costs and practices.

AVAILABILITY

Concrete wall panel producers are now located in practically every state, and in most well-populated areas there are several panel producers. Shipping panels within a 300-mile radius is common practice; and panels have been transported up to 1,500 miles and remained competitive. On some large projects and those where transportation is difficult, panels can be job-cast with subsequent savings. In the majority of cases, however, panels manufactured in well-established plants prove most satisfactory since the greatest amount of control and flexibility can be exercised under such conditions.

HANDLING AND ATTACHMENT

Handling and attachment practices followed with concrete wall panels have been perfected in the many years they have been in use. Shipment is ordinarily via trucks. Panels vary greatly in size and shape, but the 8x14-ft. rectangular panel is commonly specified since it is large enough to be economical in erection time and yet not too large for ease of transportation and handling. Panels cast at or near the job site can be larger. If panels must be transported for considerable distances, the producers must check such contingencies as heights of underpasses and highway load limitations. In most cases, contracts for supplying curtain wall panels include fabrication, transportation and stockpiling at the job site. This practice relieves the architect of such burdensome details.

Panels are often lifted directly from the truck into final position on the building. Lifting can be done by strap slings or by inserts cast in the back or edges of the panels. These inserts can also double as fastening devices. Panels can be supported by integrally cast

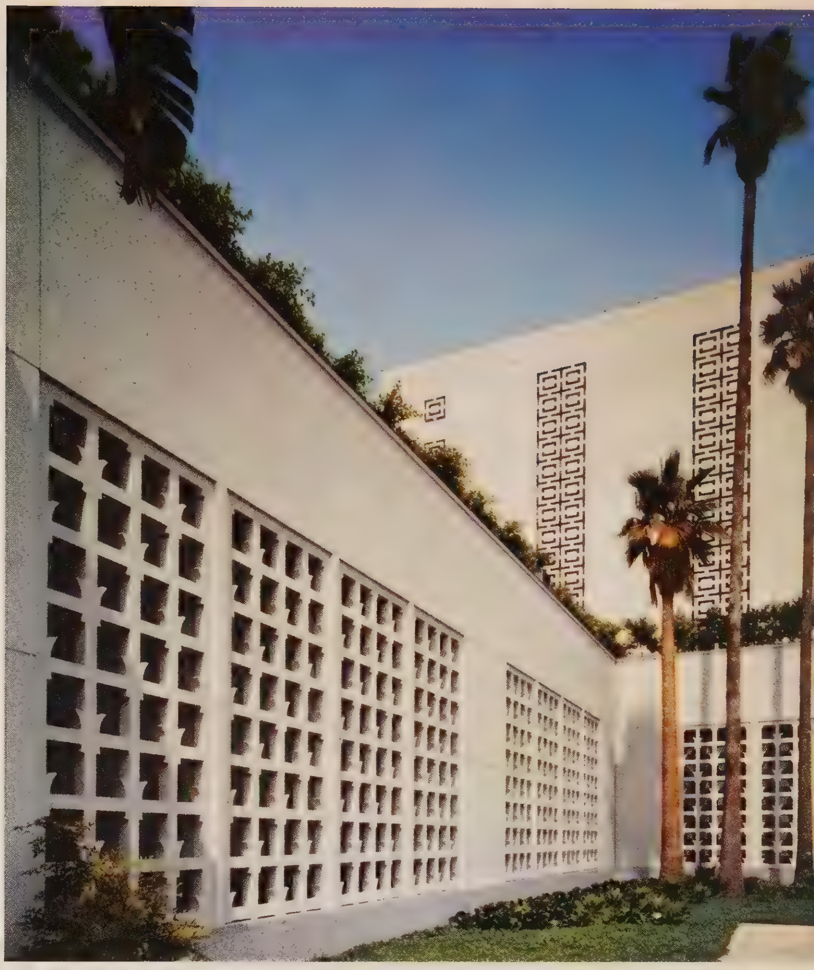


Fig. 15. *Precast grilles with exposed quartz aggregate surface conceal window areas in the Mormon Temple, Los Angeles, Calif. Architect: Edward G. Anderson. General contractor: Jacobsen Construction Co. Panel fabricator: Buehner Co. All are located in Salt Lake City, Utah.*

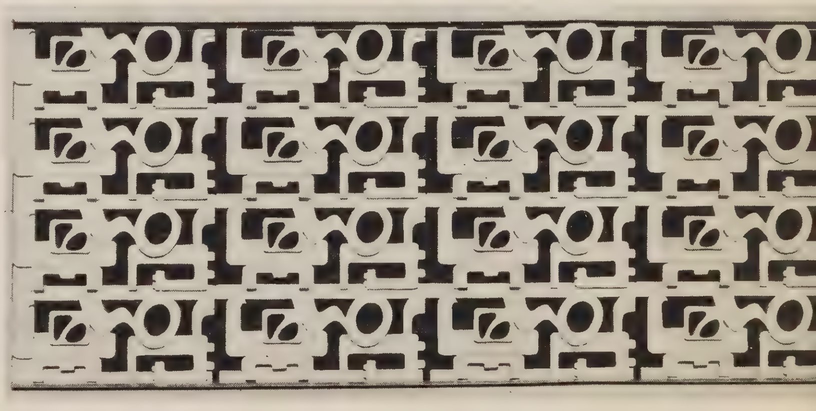


Fig. 16. *An ancient Mayan motif is the basis of design for this intricate grille in white exposed quartz aggregate.*

lugs, which eliminate expensive steel shelf angles. Many types of fastening details are available to accommodate all the possible combinations of panels and building frames. A few of these details are described in "A Few Attachment Details" beginning on page 28.

INSULATION

The swift acceptance and wide application of air conditioning have greatly increased the importance of the insulating value of walls. Heating and ventilation engineers estimate that it costs up to three times more to cool than to heat a given quantity of air. Consequently, insulation is an important factor in curtain wall construction in all areas of the country.

Lightweight aggregate concrete used as structural backing for curtain wall panels often provides sufficient insulation without need for additional materials. A panel composed of 5 in. of expanded shale aggregate concrete and a decorative surface of 1 in. of quartz aggregate concrete has a "U" value of approximately 0.34. Additional insulation may be secured by plastering the inner panel surface with vermiculite or perlite plaster. Panels 4 in. thick with an exposed aggregate facing backed with perlite concrete have a "U" value of about 0.15.

Another type with a low "U" value is the sandwich panel. These units are composed of two thin layers of concrete enclosing a layer of insulating material such as cellular glass, fibrous glass or foamed polystyrene. The total thickness of these panels ranges from 5 to 8 in., depending on insulating and structural requirements. These panels are finished attractively on both faces so that they constitute the entire wall. No further work on the wall is required once they have been fastened in place.

The effective insulation provided by this type of panel is shown by the "U" values achieved in sandwich units 6 in. thick with a 1-in. core of various insulating materials. These values range from 0.16 to 0.21 depending on the type of insulating materials used.

Concrete curtain wall panels are secured to building frames in a manner that requires no connectors or metal mullions to extend through the wall. This prevents a path of heat and cold transmission from existing between the exterior and interior of the building. Prevention of this adverse effect is one of the reasons why a building clad with concrete panels is more economical to heat and cool.

MAINTENANCE

Imagine subjecting a construction material to 145 freeze-thaw cycles per year, submergence in sea water twice daily, and exposure to the wind and other rigors of a Maine seacoast.

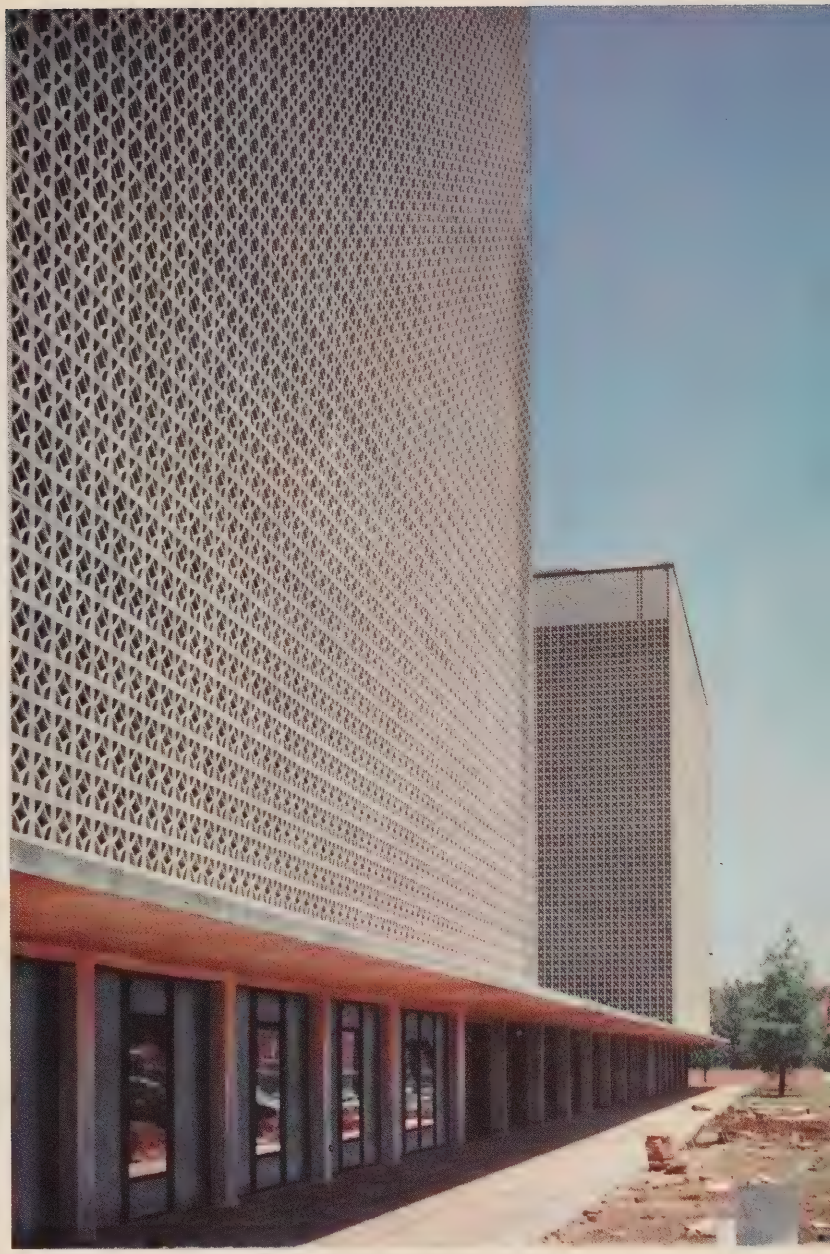


Fig. 17. *Precast concrete grille units were set up much as is concrete masonry to create the striking curtain walls for these college dormitories.*

It is under such conditions that a number of precast concrete specimens are undergoing a test at Treat Island, Maine. After five years of exposure (663 freeze-thaw cycles) there was still no sign of deterioration of practically all of the air-entrained concrete specimens. Such resistance to the effects of weathering dramatically illustrates the durability and low maintenance needs of concrete wall panels.

Since most of the surface area of an exposed aggregate panel is composed of the rugged aggregate and because matrices in these panels usually test over 6,000 psi, concrete panels are both long-lasting and fadeproof. Quartz aggregate has a hardness rating of 7.0 on Moh's scale, approximately that of carbon steel. Granite, composed of 30 per cent quartz and 70 per cent feldspars, has a rating nearly as high as quartz. Gravel and marble vary in hardness from 3.0 to 7.0 on Moh's scale. Vitreous aggregates are rated at approximately 5.5. No tests have been conducted on ceramic aggregates but it is believed that their hardness would be about that of high-grade marble. Thus, it is apparent that decorative aggregates have an expected span of usability ranging from 50 to over 200 years!

Moisture absorption rates for quartz, granite, marble and gravel vary from 0.05 to 0.50 per cent—a completely negligible amount. Moisture absorption rates of vitreous aggregates are too low to measure accurately. The moisture absorption qualities of ceramic aggregates are related to their chemical composition and length of burning. Since an extremely dense cement paste is used, moisture absorption over the entire panel is kept to a very low figure.

Because thermal volume changes in concrete panels are exceptionally small, movement at joints is kept to a minimum. When a sealant containing Thiokol liquid polymers is used, an ideal maintenance-free joint is achieved. Once a concrete curtain wall has been erected, architect and owner can be sure that the long-range cost picture will be as pleasant as the immediate one.

FIRE RESISTANCE

The excellent fire-resistive qualities of conventional concrete construction have long been recognized. These same qualities apply to concrete curtain walls. Concrete wall panels are not only noncombustible, but they also act as effective fire barriers. Such panels can be provided in the thicknesses and varieties of concrete that will conform to any building code requirement—including the maximum fire rating of four hours.

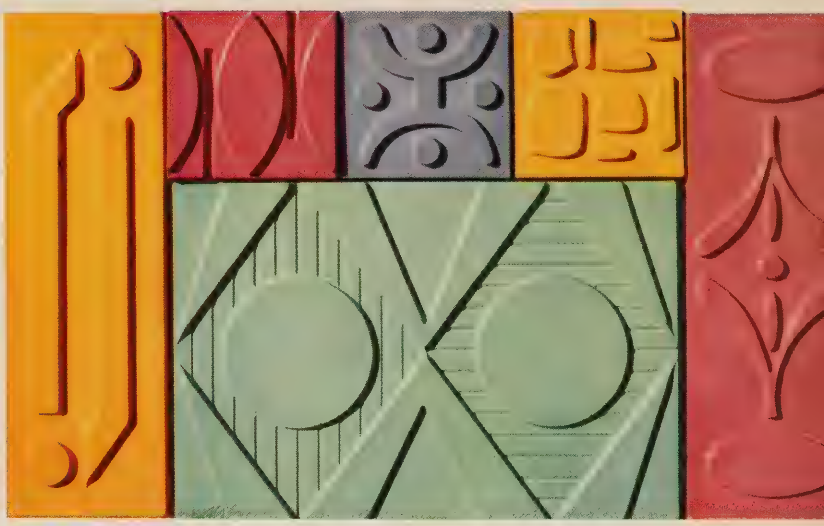


Fig. 18. *The versatility of concrete may be seen in these glossy panels cast in plastic form liners. Variety of pattern and color is unlimited.*

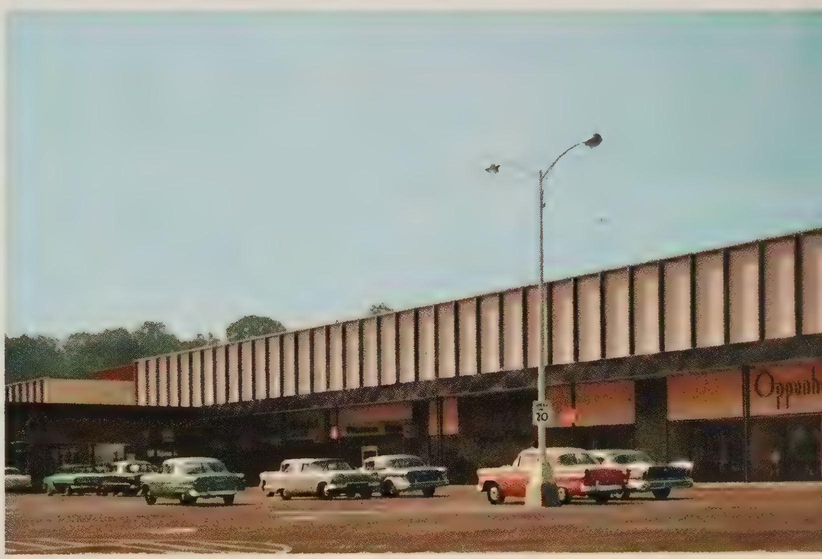
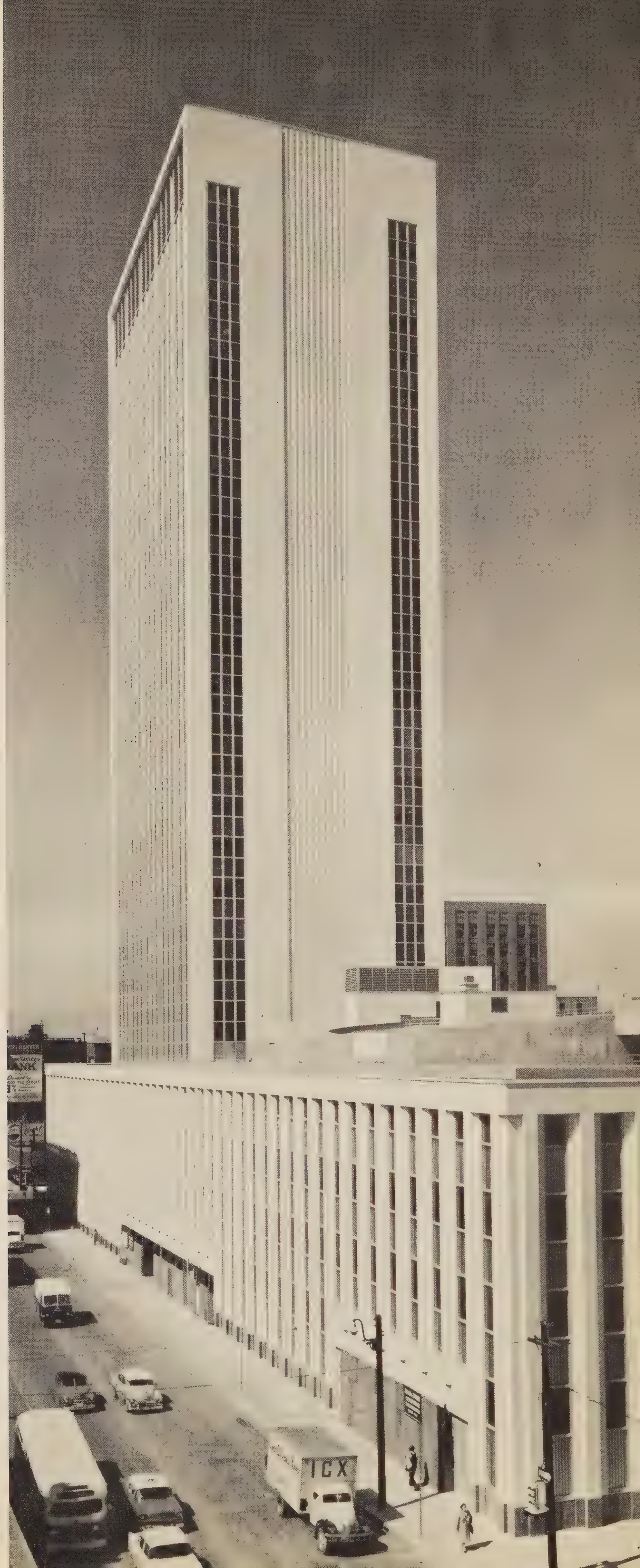


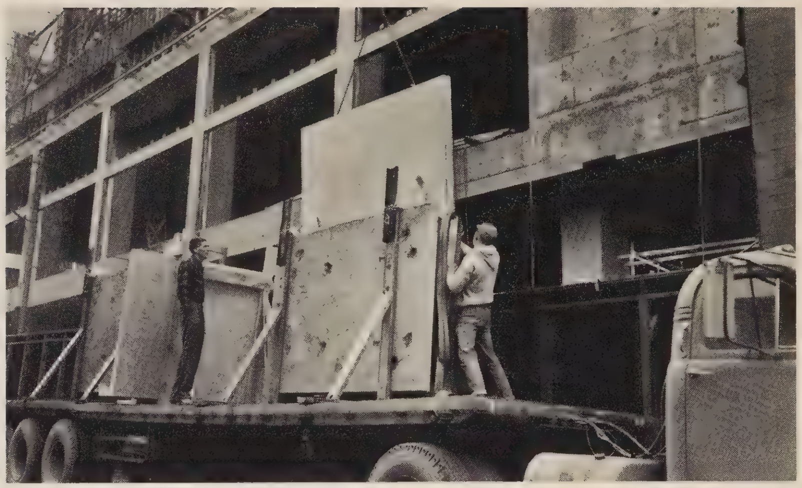
Fig. 19. *Towson Plaza, Towson, Md., a shopping center of 40 stores, owes much of its beauty to precast wall panels made with a quartz aggregate and white cement. Architect-Engineer: Leavitt Associates, Norfolk, Va. Consulting Architect: Lathrop Douglass, New York, N.Y. Owner-Contractor: Towson Plaza, Inc.; Sanzo & De Chiaro, Baltimore, Md. Panel Producer: Standard Prestressed Concrete Corp., White Marsh, Md.*

As this study of the crucial considerations in determining a suitable curtain wall material has unfolded, it has become increasingly apparent that concrete offers advantages of great importance to all concerned—architect, owner, engineer and contractor. Only concrete curtain walls combine such imposing assets in both esthetics and practicalities.

The need for compromise has been eliminated.



First National Bank Building, Denver, Colo.



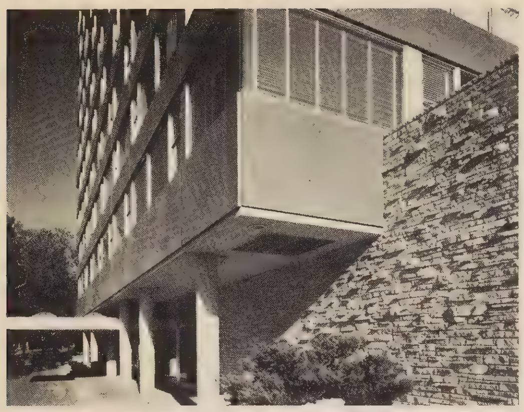
A few attachment details

There are many types of fastening or attachment devices used successfully for holding precast wall panels to building frames. The size of the panels, type of building frame and proposed appearance of the facade will influence the choice of fastening methods. Usually, the architect devises a system of attachment that will meet the demands of the design, both structurally and architecturally, and comply with local building codes. Following or during the development of fastening methods, consultation with a panel fabricator may indicate some changes to facilitate casting, handling and shipping operations and to simplify attachment to the building.

In one simple method, clip angles are cast in or welded to columns, intermediate struts, or beams, and panels are bolted or welded to the clip angles. Another method provides for supporting panels on angles that have been cast in or welded to the building frame. Inserts are welded to panel reinforcing to ensure a permanent connection. The number and location of inserts will depend on panel size and location of the column or other support.

Attachment methods used on a number of buildings are shown in Figs. 20–26.

Fig. 20.



In the 3660 Grand Apartments, Des Moines, Iowa, the precast panels were supported at floor level by angles and bolted to steel straps previously welded to the columns. Bolts were cast in the backs of panels at locations to meet the steel straps. This arrangement anticipated a moderate amount of adjustment to meet any building variations. The system proved quite satisfactory because it made it possible to place panels for each floor in less than an eight-hour shift. The vertical joints between the panels were filled with a weather-stripping material and calked.

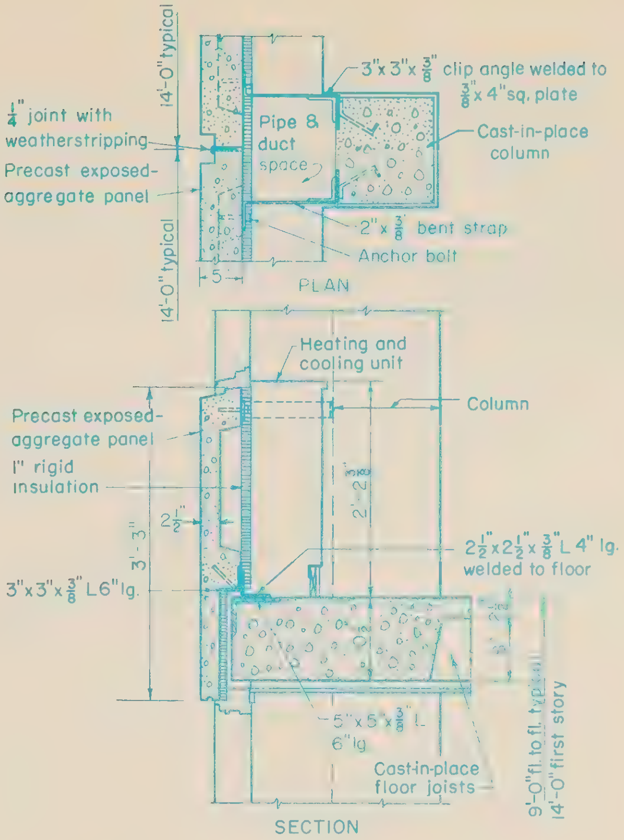
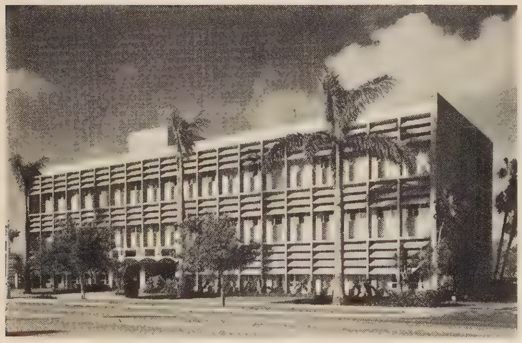

14'-0" typical
14'-0" typical
$\frac{1}{4}$" joint with weatherstripping
Precast exposed-aggregate panel
Pipe & duct space
3"x 3"x $\frac{3}{8}$" clip angle welded to $\frac{3}{8}$"x 4" sq. plate
Cast-in-place column
2"x $\frac{3}{8}$' bent strap
Anchor bolt
5
PLAN
Heating and cooling unit
Column
Precast exposed-aggregate panel
1" rigid insulation
$2\frac{1}{2}$"
3'-3"
2'-2$\frac{3}{8}$"
3"x3"x$\frac{3}{8}$" L 6" lg.
$2\frac{1}{2}$"x$2\frac{1}{2}$"x$\frac{3}{8}$" L 4" lg. welded to floor
5"x 5"x$\frac{3}{8}$" L 6" lg
Cast-in-place floor joists
9'-0" fl. to fl. typical
14'-0" first story
SECTION

Fig. 21.



Panels for the Maule Industries Office Building, Miami, Fla., were cast with inserts in the back of the units similar to those used in tilt-up panels. Bolts were cast in the building frame at the floor line and spandrel beam. A 4-ft. long, 4x4-in. angle with slotted holes was used as the connecting member between panel and anchor bolts. The slotted holes provided sufficient leeway for panels to be lined up properly with adjacent units. A high-grade calking material was used to seal the offset type of joints between panels. The system used was a simple and easy way to secure the wall panels to a building frame of this type.

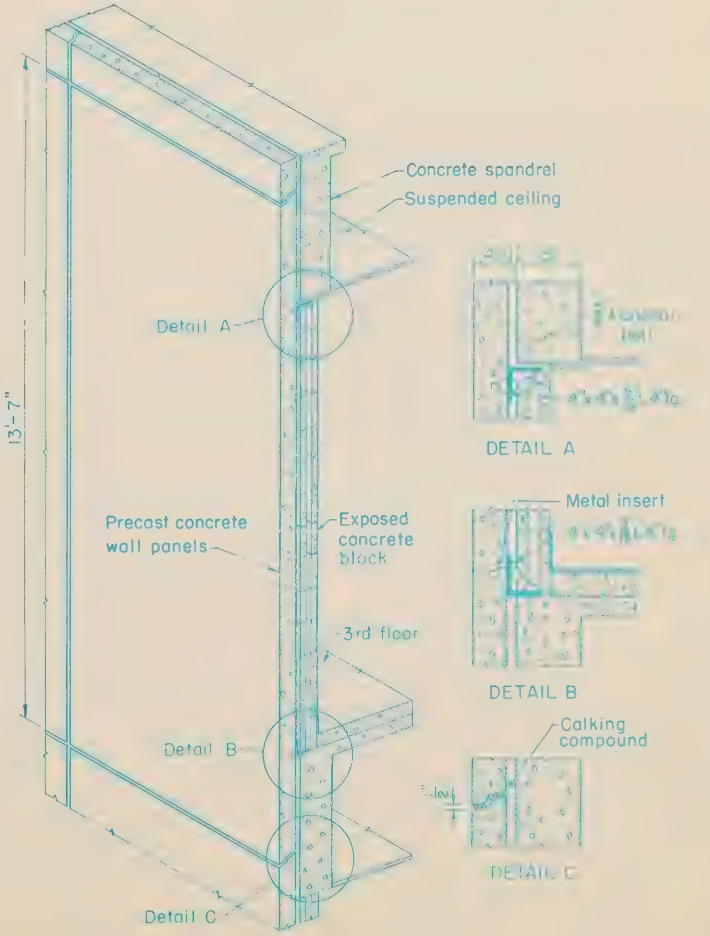
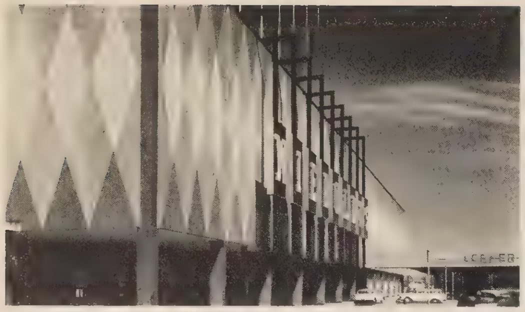
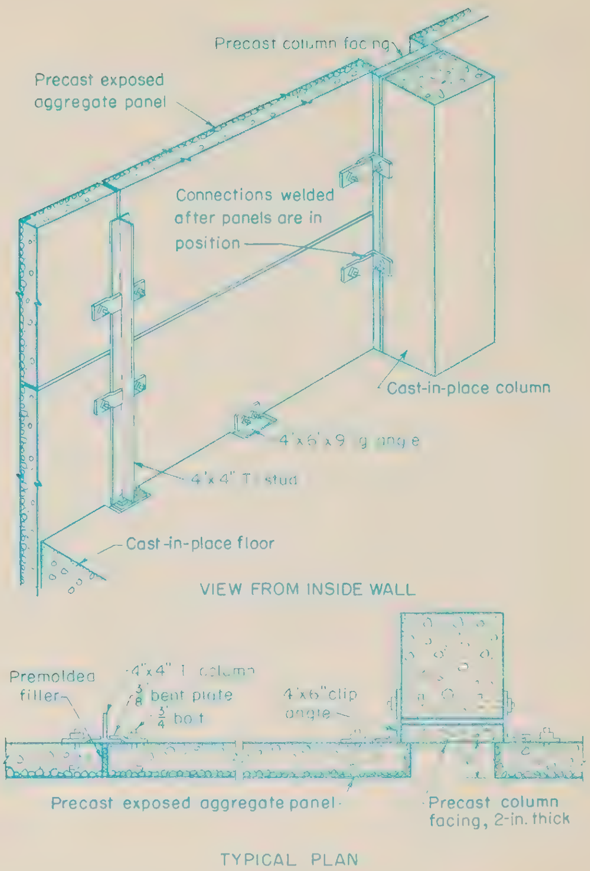


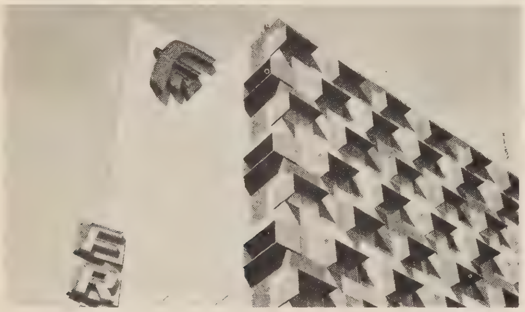
Fig. 22.

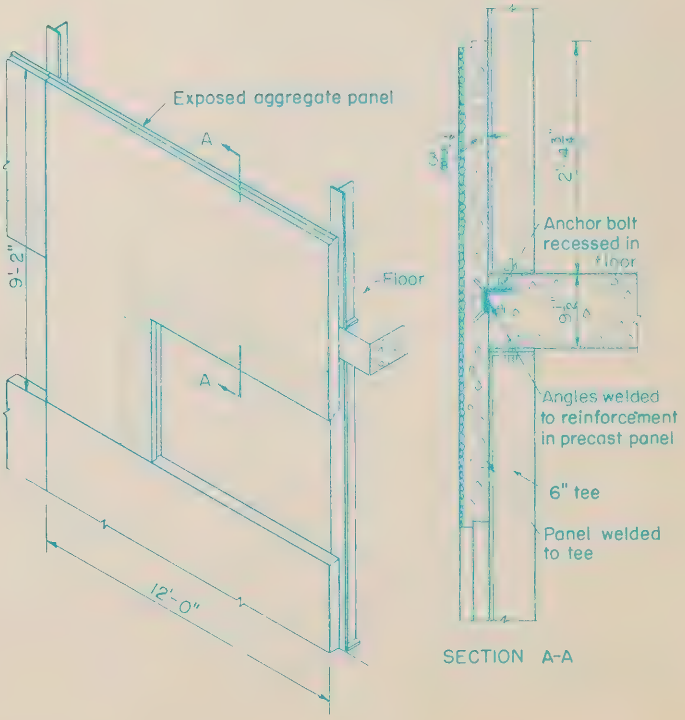




The connection details at right are for the panels on Wieboldt's Department Store in Chicago. Each bay of the building elevation requires nine 8x14-ft. panels—three horizontally and three vertically with the long panel dimension vertical. Bolts for clip angles were cast in the exterior building columns, and two tee studs were erected between floor and ceiling at the third points between columns. Inserts welded to the panel reinforcement were cast in the panels. The panels were erected by bolting to the columns, tee studs and short angle sections in the edge of the floor. After panels were aligned and in final position, the connections were welded. Premolded joint filler material was secured to the panel edges just before erection. Later, all joints were calked, front and back, with elastic calking material. The attachment system provides adequate support, rapid erection and simple fixtures.

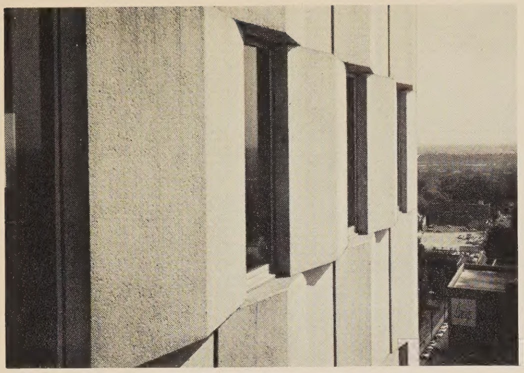
Fig. 23.





The L-shaped panels enclosing the Fremont Hotel in Las Vegas, had angles welded to the panel reinforcement and extending out the back. These were horizontal and were located just below level of the floor surface. Slots in the angles fitted over anchor bolts recessed in the floor. Six-inch tee struts between floor and ceiling were located behind vertical panel joints. Two small metal inserts cast in the panel back near each end were welded to the tee strut after final alignment of each panel. An offset type of joint was cast in the panel edges to provide a tight seal after calking. This method of attachment ensured stability of the unusual panel shapes.

Fig. 24.



In the design of the Wachovia Bank & Trust Co. Building in Charlotte, N.C., prismatic-shaped panels were developed and detailed to fit between the windows. The units were supported by lugs to the building frame and aligned by a series of 5-in. vertical channels. Removable hooks that screwed into inserts cast in one end of the panel were used to lift each unit into place on the building. Joints between panels were closed with a premolded cross-shaped gasket material and a Thiokol-base calking compound. Simple fastening fixtures permitted panels to be lifted directly from the delivery truck into final position.

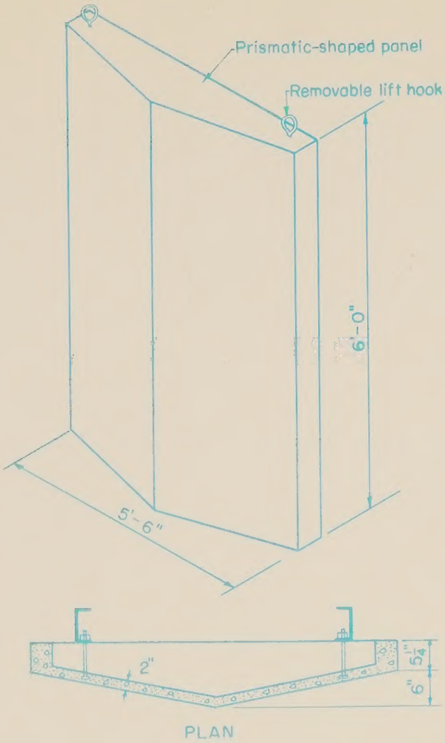
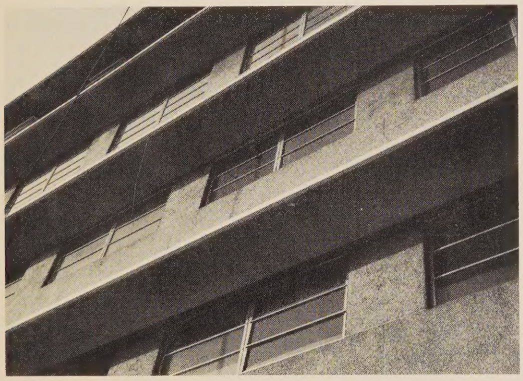


Fig. 25.



Rectangular panels on McGuire Hall Annex of the University of Virginia Medical Center in Richmond have an integral canopy. To support these large panels and secure the canopy units, a simple but effective attachment system was devised. Angles were welded to the columns and the panels seated on these members. Other angles were welded to building beams at a point below the top edge of the panel. Bolts cast in the panel back fitted into slots in these angles to hold the panels securely on the building. V-shaped joints were cast in the panel edges to provide a tongue-and-groove fit between units. A dry calking material was first forced into all joints and then sealed with an elastic calking compound.

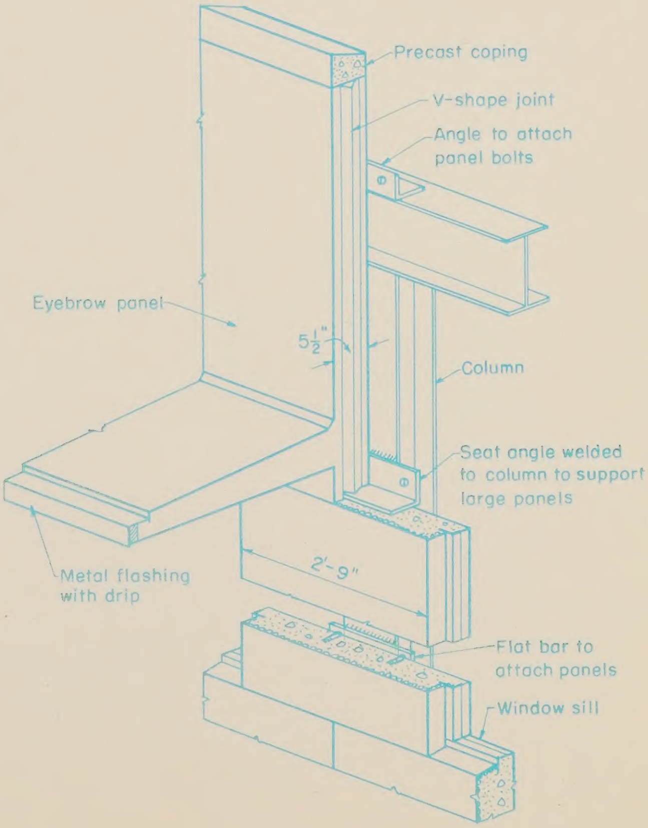
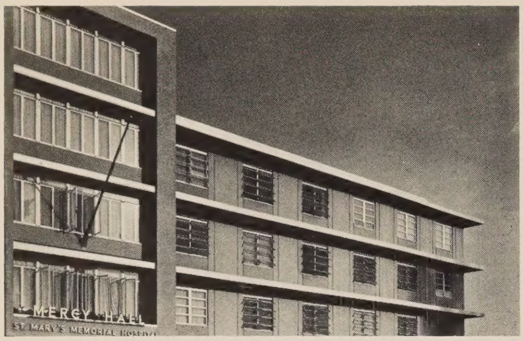

Precast coping
V-shape joint
Angle to attach panel bolts
Eyebrow panel
5½"
Column
Seat angle welded to column to support large panels
2'-9"
Metal flashing with drip
Flat bar to attach panels
Window sill

Fig. 26.



The panel attachment detail used for the Nurses' Building of St. Mary's Hospital in Knoxville, Tenn., is simple but ingenious. Concrete canopies at each floor were cast in place at the time the floor was cast. A metal channel track was welded to a floor plate cast in the concrete along the centerline of the exterior wall. Directly above this, two angles were secured to the ceiling parallel to but separated by the width of the precast panel. Small steel plates were cast in the bottom edge of the exposed aggregate sandwich panels to act as runners or shoes. Panels were then slid into position from one end of the building, a method that proved to be fast and simple. The bottoms of the units were grouted into place and metal flashing installed. The overhead angles were concealed with aluminum covers.

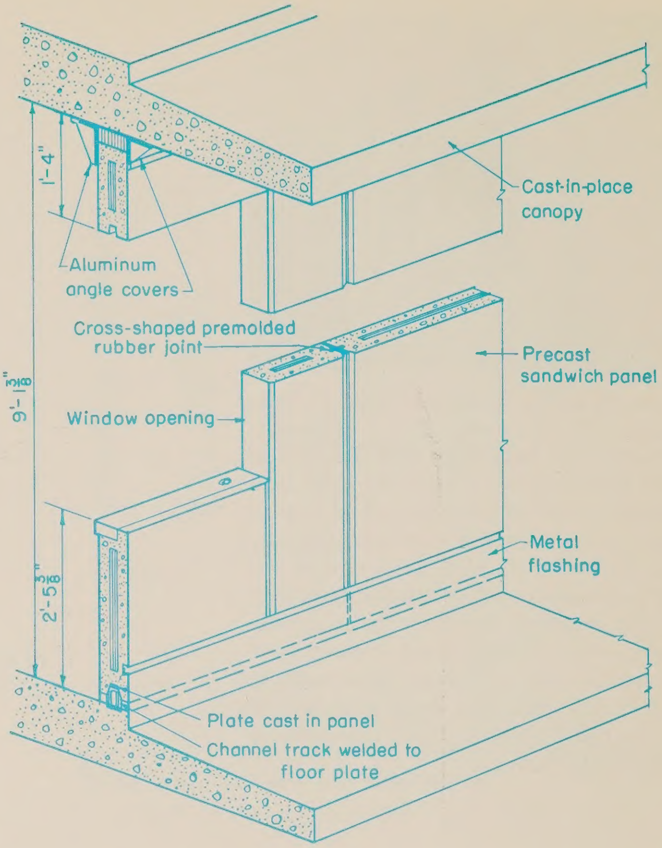
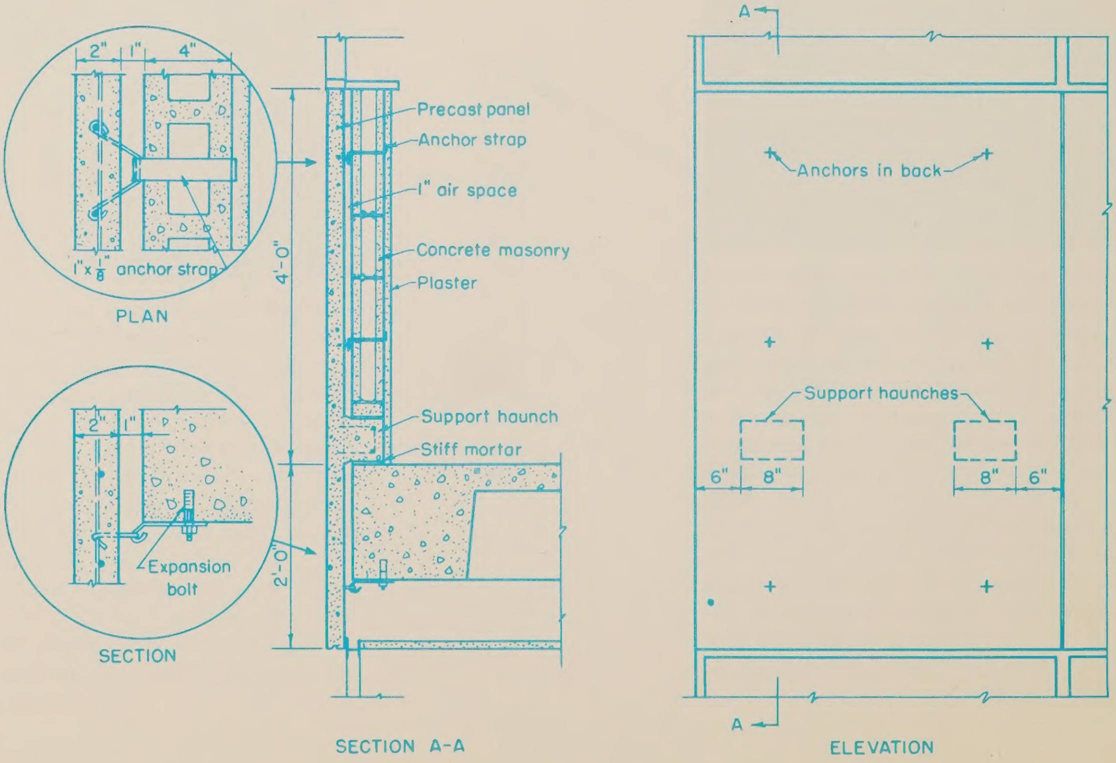


Fig. 27. *A detail commonly used for supporting thin facing panels is shown below. Lugs or supporting haunches, integrally cast in the back of the panel, bear on the floor slab. Such lugs are easy to cast and usually lower erection costs.*



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